

# Section 3.8 Receipt Vessel Rupture



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# Section 3.8 Receipt Vessel Rupture

## 3.8.1. Work Identification

This section demonstrates an application of the integrated safety management process to an example of receipt tank rupture. This report focuses on the control of hazards associated with the rupture of the high level waste (HLW) receipt vessels in the pretreatment facility.

HLW from DOE will be received into the TWRS-P pretreatment facility for treatment and blending with other components (Sr/TRU solids, Cs/Tc solution and selected plant waste recycle streams) as feed for the HLW Melter. The HLW can consist of HLW solids washed by DOE (Envelope D) or unwashed solids. The unwashed solids can be transferred with one of the low activity waste (LAW) feeds (Envelopes A, B and C). BNFL Inc. has proposed to only receive unwashed solids from the DOE. A final decision has not been made on that proposal. This example has assumed the receipt of unwashed solids.

Three vessels, V31001A/B and V31002, receive the HLW from DOE. It is then transferred to the ultra filtration feed Vessels V32001 A/B. The solids are concentrated and washed in the ultra-filtration loops. Batches of the washed and concentrated solids are transferred to Vessels V310001A/BC/D/E for storage at 25 weight percent. From these vessels, the solids are transferred to the HLW Feed Blending Vessels V32004 A/B. After blending, the solids are transferred to the HLW Melter Feed Preparation Vessel V11001 through the HLW Melter Feed Buffer Vessels V11003 and V11004.

In total, twelve vessels in the TWRS-P facility can contain concentrated washed solids. Figures 3.8-1 and 3.8-2 show the locations of these vessels in the process. Table 3.8-1 provides the vessel designations and descriptions. The HLW Receipt Vessels V31001 A/B/C/D/E have been chosen for evaluation because of their large volume in comparison to the other vessels. The basis of this example is the process as described in (BNFL Inc. 1998a,b,d,e).

Vessel Designation	Vessel Description	Vessel Volume U S gal (m³)
31001 A/B/C/D/E	HLW Receipt Vessel	59,400 (225)
32001 A/B	Ultra-filtration Feed Vessel	18,200 (69)
32004 A/B	HLW Feed Blending Vessel	1,800 (6.88)
11003, 11004	HLW Melter Feed Buffer Vessel	2,750 (10.4)
	HLW Melter Feed Preparation	
11001	Vessel	2,350 (8.9)

Table 3.8-1. Vessels Containing Concentrated HLW Solids

#### 3.8.1.1. Key Process and Design Parameters

During the operating lifetime of the TWRS-P facility, the HLW Receipt Vessels will contain hazardous material from several sources in the Hanford Tank Farms. As discussed further below, from the

standpoint of radiological dose consequences, the concentrated and washed solids from Hanford Tank 241-AZ-101 (one of the early processing feeds) presents the bounding material at risk (MAR) for the hazard addressed in this report.

The early processing feed consists of a combination of Envelope B and Envelope D (Envelope B and D Sludge). Both of these envelopes exist in Tank 241-AZ-101 and Tank 241-AZ-102. The waste in these tanks consists of supernatant and settled solids. Envelope B is the supernatant (solution) and soluble solids from the settled solids in the tanks. Envelope D is the insoluble settled solids in the tanks.

Tank 241-AZ-101 was picked as the basis for the MAR because it contains the highest concentration of radionuclides of concern ( $^{90}$ Sr and  $^{241}$ Am from inhalation dose). Table 3.8-2 shows the primary radionuclides associated with the solids for each of the Phase I Envelope D feed tanks. Table 3.8-2 also lists the mass of washed solids, the percentage of washed solids retrieved, and the resultant washed solids that could be stored in vessels V31001A/B/C/D/E. Based on the data above, Table 3.8-3 shows the amount of curies of the  $^{90}$ Sr and  $^{241}$ Am per 100 grams solids. As can be seen from, Tank 241-AZ-101 has the highest concentration of  $^{90}$ Sr and  $^{241}$ Am and therefore will be used as the basis of calculation for this example.

Table 3.8-2. Phase I Envelope D Feed Tanks (Activity Decayed to January 1, 1994)

Tank	<sup>90</sup> Sr (Curies)	<sup>241</sup> Am (Curies)	Washed Solids (Kilograms)	Percent Retrieved	Stored Washed Solids (Kilograms)
241-AZ-101	6,360,000	22,600	130,000	90	117,000
241-AZ-102	3,700,000	14,800	222,000	60	133,000
241-AY-102	2,470,000	2,870	N/A	N/A	Combined with 241-C-106
241-C-106	4,770,000	1,120	309,000	85	263,000
241-C-104	630,000	6,700	480,000	100	480,000

Table 3.8-3. Strontium-90 and Americium-241 Concentration -- Curies per 100 Grams of Retrieved Washed Solids (Activity Decayed to January 1, 1994)

Tank	<sup>90</sup> Sr (Ci/100 g)	<sup>241</sup> Am (Ci/100 g)
241-AZ-101	5.4	0.0193
241-AZ-102	2.8	0.0111
241-AY-102	N/A	N/A
241-C-106	2.8	0.0015
241-C-104	0.1	0.0014

As shown on Figure 3.8-1, the slurry is received from DOE in Vessels V31001A, V31001B, and V31002. The waste is fed from V31001B or V31002 to Vessels V32001 A/B – the ultrafiltration feed vessels. The

concentrated solids from the ultrafiltration loop are transferred back to V31001, pending vitrification<sup>a</sup>. These solids have been washed to remove soluble species (e.g., Na and Cs) and concentrated for storage.

Pretreatment concentrates the solids either to 20 weight percent for feed to the HLW melter or to 25 weight percent for storage during early processing. Storage of 25 wt% was used for this MAR. At that concentration, storage of the Tank 241-AZ-101 activity would require a total slurry volume of 103,000 US gal (390 m³). The process requirement is to store all of the washed solids arising from tanks 241-AZ-101 and 241-AZ-102. This requirement is satisfied by concentrating the washed solids to 25 wt%. **Operating Assumption.** It is unlikely that a higher concentration would occur because of material handling concerns.

Table 3.8-4 compares the radiological dose potential of the unwashed, unconcentrated solids that are received from Hanford Tank 241-AZ-101 and stored in vessels V31001 A/B and V31002 -- to the washed, concentrated solids stored in vessels V31001A-E. The radioactivity concentrations for "receipt" are obtained from the Best-Basis Inventory (WHC 1998a). The radioactivity concentrations for "storage" represent washing to separate out the cesium inventory, concentration to 25 wt%, and decay to January 1, 2006. The dose conversion factors are obtained from EPA 1988. Table 3.8-4 shows that the "dose potential" of the radionuclides of concern is greater for the "Stored" condition than for the "Receipt" condition. Therefore, storage of washed, concentrated solids from 241-AZ-101 represents the bounding MAR for dose consequences. **Design Assumption.** 

Table 3.8-4. Comparison of Dose Potential from Tank 241-AZ-101 Solids

#### Radionuclide **Activity Concentration (Ci/l) DCF** Unit Liter Dose (rem/L) (rem/Ci) Receipt Storage Receipt Storage 90Sr 8.1 12 $2.39 \times 10^{5}$ $1.94 \times 10^6$ $2.87 \times 10^6$ <sup>137</sup>Cs 5.4 $3.19 \times 10^4$ $1.72 \times 10^5$ $0.00 \times 10^{0}$ 0 <sup>241</sup>Am 0.038 $4.44 \times 10^{8}$ $1.69 \times 10^7$ $2.58 \times 10^7$ 0.058 $1.90 \times 10^7$ Total $2.86 \times 10^{7}$

#### Received Solids versus Stored Washed Solids Material at Risk

During Part A, the Contract specified that the U.S. Department of Energy (DOE) would transfer washed solids (Envelope D) to the BNFL Inc. facility for processing. The negotiations between the DOE and BNFL Inc. included an agreement to assess early processing of waste as a contract modification (Specification 12), with solids washing occurring at BNFL's facility rather than in DOE's tanks. Furthermore, instead of all operations starting concurrently, this modification includes the pretreatment of the Envelope B and D sludge waste in Tanks 241-AZ-101 and 241-AZ-102 prior to the start of vitrification operations. Once Envelope B is pretreated to remove soluble radionuclides (by ion exchange), the supernatant would be returned to a Double Shell Tank for storage. The pretreated solids from washing would be stored in four or more vessels in the TWRS-P facility until High-Level Waste (HLW) Vitrification begins.

As such, the long-term storage of solids with a large inventory of radionuclides was not addressed in the Part A Hazard Assessment. The Part A assessment examined receipt in three vessels of the washed solids from the DOE. At present, the assessment of this process change has added two vessels (of the same design as the HLW Receipt Vessels) to the facility and modified the Strontium and Transuranic Precipitation Vessel to support this process change. Thus, the number of vessels for receipt and storage of HLW solids prior to HLW Feed Blending Vessels has increased (i.e., from three to six).

#### 3.8.1.1.1. Detailed Process Description

The following process description expands upon the summary discussion above. It is applicable only to the first years of pretreatment (i.e., the pretreatment of the contents of Tanks 241-AZ-101 and 241-AZ-102). After the first years of operation, the HLW melter operates at capacity to work off the solids from pretreatment. The largest stored inventory of radionuclides will occur during the pretreatment period.

#### Receipt of HLW Feed from the DOE

HLW Pretreatment in Accordance with Specification 12 (BNFL Inc. 1998f) outlines the preferred configuration for the receipt and treatment of HLW feed. This configuration is as follows. The initial batch of Envelope Band D sludge feed from the DOE [158,500 US gal (600 m³)] is received by the pretreatment facility into the HLW Receipt Vessels V31001A/B [59,400 US gal (225 m³)] and into the Strontium/TRU Precipitate Vessel V31002 [59,400 US gal (225 m³)]. After the first transfer, the volume transferred will be limited to between 52,800 and 105,600 US gal (200 and 400 m³).

The contents of V31001A will need to be transferred to V31001B before being fed to the ultrafilter feed vessels, because there is no route from V31001A to the ultrafiltration feed vessels. V31001A/B may continue to serve as feed receipt tanks until they are required to be used for lag storage of the pretreated solids. Once these two vessels are filled, subsequent batches of 52,800 US gal (200 m³) each will be fed to the Sr/TRU precipitation vessel V31002 during the first years of operation.

#### Lag Store HLW Solids

Solids from ultrafiltration are routed to V31001E in batches of up to 18,500 US gal (70 m³) each. The actual size of the batch will depend on the starting solids content of the ultrafilter feed and on the effectiveness of the water washing and/or caustic washing operations. Once V31001E becomes full, the solid slurry is transferred to either V31001C or V31001D. From these vessels, the slurry can only be transferred back to V31001E or to V31001B (from V31001C) or to V31001A (from V31001D). The order of vessel filling is postulated to be V31001A, V31001D, V31001B, V31001C, and finally V31001E. On average, each vessel will contain approximately 52,800 US gal (200 m³) of 25 wt% HLW solids at the end of this early pretreatment operation.

#### 3.8.1.1.2. HLW Receipt Vessel Design Parameters

To support process requirements, the transfer patterns associated with these vessels differ slightly from each other. Differences result from material handling considerations given to internal facility transfers.

The key design parameters for the HLW vessels are as follows (BEL 1997):

Total volume	=	75,280 US gal	$(285 \text{ m}^3)$	
Overflow Volume	=	62,100 US gal	$(235 \text{ m}^3)$	(85% of total)
Maximum Operating Volume	=	59,400 US gal	$(225 \text{ m}^3)$	(~80% of total)
Operating Volume	=	52,000 US gal	$(197 \text{ m}^3)$	(~70% of total)
Operating Head Space	=	23,250 US gal	$(88 \text{ m}^3)$	
Material of Construction	=		SS 304L	
Head/Shell Thickness	=	0.63 in.	(16 mm)	

The material of construction for storage vessels was selected based on its ability to resist corrosion and erosion and to provide continued service over the useful design life of 40 years.

The HLW storage vessels are all equipped with cooling capability to facilitate temperature control during extended storage periods. Vessel contents are monitored for level and temperature at a minimum. All process nozzles exit or enter from the top of the vessel (no side penetrations).

The number of reverse flow diverters (RFDs) in a particular vessel is determined by transfer requirements. Each vessel is equipped with mixing capability (pulsed jet mixers). The number of mixers employed will be adequate to insure complete mobilization of the solids. Both pulsed jet mixers and RFDs are employed in preference to maintainable items to reduce downtime and exposure to workers.

Pneumercators provide liquor level measurement.

The vessels normally operate at a temperature of 40 °C and a pressure which is slightly negative with respect to the cell. Cooling coils are provided in the vessels to maintain the temperature and the contents are regularly mixed to maintain their homogeneity. The vessels are vented to the vessel ventilation system which has a filtered discharge.

#### 3.8.1.2. Interfaces

The present V31001A/B vessel design has interfaces with the normal and standby cooling water systems to maintain the temperature of the vessel contents. A vessel vent header is provided to remove vapors, aerosols and other gases evolved from the vessel contents and to maintain the vessel at a negative pressure with respect to the process cell. A facility ventilation system (C5 cell ventilation) provides a controlled, filtered route for removal of contamination from the cell and maintains the process cell at a negative pressure with respect to occupied areas of the facility. Plant compressed air is provided for the pulsed jet mixers and reverse flow diverters. Instrument air is provided to the pneumercators. Wash reagents are supplied via wash cabinets.

#### 3.8.1.3. Operating Environment and Setting

The material housed in the HLW Receipt Vessel is alkaline in nature. The HLW Receipt Vessels are located in the pretreatment facility at the –46 ft (-14 m) elevation in the B&D receipt cell in a single cell (Figure 3.8-2). The cell in question has a stainless steel cell liner which is sized to take the full contents of the largest vessel and a sump which is routed via an ejector to the HLW drain system, a series of collection vessels from which effluent is monitored to allow sentencing for further treatment or to drain. The sump has level monitoring instrumentation for the detection of leaks in the cell. The vessels are located in a shielded, ventilated cell.

#### 3.8.1.4. BNFL Experience

BNFL's operations in the UK utilize a wide range of vessels containing various levels of radioactive liquors. This amounts to many thousands of vessel years operating experience. The most demanding requirements are associated with the Highly Active Storage Tanks at B215, Sellafield which have been operating successfully for up to 40 years. The liquors in these vessels present a much greater design challenge in terms of radioactive inventory and heatload than any of the liquors anticipated for the TWRS-P project. They are also acidic in nature. The liquor holding tanks at EARP contain alkaline LAW. These vessels have now been operating successfully for approximately nine years.

Continued improvements in design mean that much of the data from operating experience of components similar in duty to the HLW receipt vessel is predominantly from vessels which are of a lower integrity than those BNFL is currently designing. In particular they do not incorporate the levels of analysis, and design features such as fillet welds, which BNFL would consider appropriate for today's vessels. There have been no major failures of such vessels. For recent projects including THORP, improved grain flow specification for forged branches with a requirement for weld buttering has been introduced. Material specifications have also been improved.

## 3.8.2. Hazard Evaluation

#### 3.8.2.1. Hazard Identification

For this example, the hazard arises from release of radioactive materials contained in the HLW receipt vessels. The rupture of one of these vessels could result in significant consequences to the facility worker, the co-located worker and the public. For the selection of an initiating event, the following potential initiators were considered (Table 3.8-5).

**Table 3.8-5. Potential Initiators** 

Type	Event Initiator	Hazard Scenario	Comments
Material fracture, corrosion/erosion, fatigue, weld failure	Out of specification feed material	Unexpected components of the feed material could increase corrosion of the tank material.	The feed will be within the contract specification and therefore the tank materials will be compatible with the process fluid. There is no identified potential for the addition of chemicals which will render the waste incompatible with the tank materials.
As above	Corrosion due to internal or external equipment	Corrosion/erosion of tank material	Equipment is not attached directly to vessel walls so corrosion resistance of vessel not directly challenged. Erosion plates in place near to internal mixers.
As above	Stresses due to internal or external equipment.	Material weakened due to fatigue (e.g., thermal and pressure cycling in steam ejector systems).	Fatigue analysis to verify adequate lifetime support of vessel internals and external pipework.
As above	Material or manufacturing defect	Defects in tank material or at welds could increase the potential for corrosion or fracture.	Materials selection and inspection assure quality. All welds below liquor line are fully radiographed. Branches are all above liquor line.
As above	Poor QA on construction/installation	Weld failure	Inspections and QA procedures in place at all levels of design, installation and commissioning. Multiple procedural failures would be necessary.

Table 3.8-5. Potential Initiators

Type	Event Initiator	Hazard Scenario	Comments
External Impact	Dropped load	A dropped load during a flask transfer over the cell roof causes impact on the tank.	There are no mechanical handling operations in cell and the cell will be designed to protect vessels from impact from operations in the surrounding areas. This is discussed in Section 3.3.
As above	External event, or a high energy event nearby (same cell or adjacent cell)	High velocity projectile hits the tank and causes vessel rupture	External hazards are considered in Section 3.8.2.6.2. High energy systems nearby (e.g., steam lines) are subject to stress and fatigue analysis to ensure correct support/retention.
Toppling tank	Seismic event	Seismic forces could cause the tank or supports to fail.	The tank and its supports will be qualified to withstand the design basis seismic event.  Safety Function.
As above	Flotation due to leak in cell	A significant in-cell leak could cause the tank to float and topple, or be crushed if submerged.	The supports will be sufficiently robust to hold the empty (worst case buoyancy) tank in position in the event of a flood. The tank will resist crushing. <b>Safety Function.</b>
As above	Support failure	Defects, in construction or installation or poor specification could result in failure of the tank support	Adequate tank support specified in design and subject to inspection and QA procedures on installation and commissioning.
Overpressure	Presence of gas	Tank subject to excess pressure resulting in explosion/burst	The potential for hydrogen generation within the tank is discussed in Section 3.1. The design will incorporate control strategies to avoid explosive concentrations. The tanks are vented, and no other source of pressurization has been identified.

BNFL vessel design practices already address all the potential initiators identified in Table 3.8.2-1, as indicated. None of these is therefore considered a likely failure mode. All will be considered in detail during design development. The initiator which has been chosen is weld failure. This stems from human error in execution and inspection. It is assumed that an inadequate weld goes undetected and ultimately fails in service.

The cell has a cell liner and sump which is routed to the HLW drain system, thus, there is no mechanism for a leak to ground to occur from failure of the receipt tank alone. However, failure of the cell liner could occur from damage due to a toppling tank or similar event. This mechanism for leak to ground will be considered in a separate analysis and is therefore not considered further in this report. **Open Issue.** 

At the detailed design stage, the shielding thickness of the cell will be based on the worst case release into the cell. **Safety Function.** Therefore, direct radiation dose to the facility worker outside the cell is not considered further.

#### 3.8.2.2. Event Sequence

The specific event is catastrophic failure of the HLW Receipt Vessel due to human error in execution and inspection resulting in a weld failure. The vessel failure spills the entire contents of the vessel onto the cell floor. The liquor impacting the floor forms an airborne aerosol. Airflow over the surface of the spilled material entrains additional radioactivity after the spill. The airborne radioactive material is assumed to be removed by the cell ventilation system and released to the environment or to migrate out of the cell through penetrations in the walls.

#### 3.8.2.3. Unmitigated Consequences

Calculation CALC-W375PT-NS0001 (Kummerer 1999) assesses the potential unmitigated consequences from a vessel rupture. The bases for this consequence assessment are as follows:

- 1. The HLW receipt vessels will contain a variety of materials over the life of the facility as described in Section 3.8.1. Of these materials, the washed solids from AZ-101 are the most onerous in terms of consequences. Therefore, the unmitigated consequence assessment is based on washed AZ-101 solids. The bounding inventory of radionuclides in the vessel is the inventory of AZ-101 solids in the vessel when it is filled to the overflow level [62,100 US gal (235 m³)].
- 2. The inventory of AZ-101 solids requires 103,000 US gal (390 m³) of storage capacity. Therefore, 62,100 US gal (235 m³) of washed solids represents 235/390 = 60% of the total radionuclide inventory associated with AZ-101 solids. This represents 2.8 MCi of <sup>90</sup>Sr, 0.014 MCi of <sup>241</sup>Am and smaller amounts of other fission and corrosion products.
- 3. The Sellafield database (BNFL plc 1997) recommends estimating the release from large scale or continuous spills of liquor based on an aerosol concentration of 10 mg/m<sup>3</sup> in the cell airspace. This consequence assessment adopts this recommendation.
- 4. A second mechanism for airborne release is resuspension in airflows over the pool that is left after the spill. The respirable airborne release rate for pools inside buildings subjected to normal building ventilation flow is 4.0 x 10<sup>-7</sup> per hour (DOE 1994) a conservative figure for releases inside buildings.
- 5. The consequence assessment assumes that the concentration of radioactivity in the aerosol is the same as the concentration of radioactivity in the vessel (that is, the radioactivity per gram of aerosol equals the radioactivity per gram of vessel liquor). This is a very conservative assumption because the radioactivity is associated with the suspended solids, not with the vessel liquor which forms the aerosol.
- 6. This consequence analysis credits two passive barriers that are not challenged by the spill scenario: the cell fabric and the passive elements of C5 extract system. The assessment takes the following credit:

It is assumed that the extract filters are in a failed condition. However, some of the airborne material will be retained within the process cell or the ventilation ductwork because of settling and plateout. A decontamination factor for hold up in ventilation ducts or failed filters of 10 is used (BNFL plc 1997). **Design Assumption** 

A decontamination factor of 100 has been applied across the cell barrier assuming the C5 extract system has failed. (BNFL plc 1997). **Design Assumption.** 

- 7. The assessment assumes that the vessel has failed catastrophically and all of the liquor spills out of the vessel in a manner which maximizes the in-cell concentration. This is assumed to continue for one hour. Therefore, the atmospheric dispersion coefficient used to evaluate the dose from the aerosol generated by impact does not account for plume meander. The release of radioactivity by entrainment from the pool of spilled liquor takes place over several hours. Therefore, the atmospheric dispersion coefficient used to evaluate this contribution does account for plume meander. The atmospheric dispersion model accounts for building wake effects in both cases.
- 8. This assessment estimates the unmitigated dose to the facility to the facility worker based on a two hour exposure. This exposure time is appropriate because the areas adjacent to the cell containing the HLW storage vessels are normally unmanned (that is, personnel are not present continuously, as, for instance, could be the case for a manipulator station). **Operational Assumption.**
- 9. This assessment estimates the unmitigated dose to the co-located worker based on an eight hour exposure and the unmitigated dose to the public based on a 24 hour exposure. This is in accordance with the BNFL, Inc. Code of Practice for Accident Analysis process, K70C505.

The results of the unmitigated consequence assessment are provided in the following table:

#### **Unmitigated Dose Consequences**

Population	Dose (rem)	Severity Level
Facility Worker	6	SL-2
Co-located Worker	6.9	SL-2
Public	0.023	SL-4

<sup>&</sup>lt;sup>a</sup>Dominant pathway is inhalation.

#### **3.8.2.4.** Frequency of the Initiating Event

The Sellafield Reliability Database (BNFL plc 1998) quotes a weld failure rate leading to catastrophic failure of 1 x  $10^{-5}$  per year for unpressurized vessels in non-aggressive conditions. There are 12 similar vessels in the facility as described in Section 3.8.1. which could potentially contain the material assessed in this report. The initiating event frequency is therefore taken as  $1.2 \times 10^{-4}$  per year.

#### 3.8.2.5. Common Cause and Common Mode Effects

No common cause or mode effects other than the human performance factors inherent in the event were identified as likely to be significant contributors to accident frequency.

#### 3.8.2.6. Natural Phenomena Hazards and Man Made External Events

#### 3.8.2.6.1. Natural Phenomena

Natural phenomena hazards and their treatment on a plant-wide basis are included in Section 2.10. **Design Assumption**. Of these, seismic and in-cell flooding events are a clear potential initiator for vessel rupture which needs to be addressed. Flooding will be considered as a design load for the cell and vessel, and hence will not prevent a risk to the vessels. **Design Assumption, Safety Function.** 

#### 3.8.2.6.2. Man Made External Events

Similarly, man-made hazards and their treatment on a plant wide basis are also discussed in Section 2.10. There are no man-made hazards that uniquely effect this event.

# 3.8.3. Control Strategy Development

#### 3.8.3.1. Controls Considered

The consideration of multiple alternative control strategies for this hazard has not been carried out since a mature, proven strategy already exists within BNFL for the handling and storage of radioactive liquors. (DOE-RL, 1998a). The control strategy consists of primary (vessel) and secondary (cell) confinement and a C5 filtered extract ventilation system.

Primary containment is provided by a high integrity vessel and support structure. The secondary confinement comprises a shielded cell of sufficient thickness to provide protection to the facility worker from direct radiation during normal operations and due to off normal events. The cell structure is such that penetrations are minimized and those that are necessary are well sealed to prevent migration of activity to operating areas. There is an engineered inlet to the cell to provide a route for supply air to the C5 extract ventilation system. An inlet filter is included to prevent blowback of activity to operating areas in the event of a cell pressurization. The cell is stainless steel clad to the height required to accommodate the largest spill to prevent the environmental impact of release to ground.

The C5 extract ventilation system provides a controlled route for the removal of contamination due to an accident in the cell. Further protection against migration of activity to operating areas is afforded by maintaining the cell at a pressure slightly negative to the surrounding areas. The C5 extract ventilation fans are sized for this duty and duty/standby provision with automatic start of the standby fan in the event of duty fan failure is standard practice. The system includes a primary and secondary bank of HEPA filters to prevent release of radioactive material to the environment.

#### 3.8.3.2. Structures, Systems, and Components that Implement the Control Strategy

The SSCs that implement the selected control strategy for the receipt vessel rupture are:

- The vessel and its associated support structure which contain the liquor. Safety Function.
- The cell structure and cladding which contain any spill and aerosol. Safety Function.
- The C5 ductwork, filters and extract fans (and associated services) which mitigate airborne activity release. **Safety Function.**

# 3.8.4. Safety Standards and Requirements

The safety standards and requirements for these elements are determined according to K70C514, Code of Practice for Development of Control Strategies and Identification of Standards. Table 3.8-6 provides the

design data leading to the selection of safety standards and requirements for the systems, structures and components that make up the selected control strategy for the HLW Receipt Vessel Rupture.

#### 3.8.4.1. Reliability Targets

The initiating event frequency, taking account of all 12 vessels, which contain equivalent material at risk, has been calculated as  $1.2 \times 10^{-4}$  per year. This is based on operational failure data for vessels of  $10^{-5}$ /y/vessel. Since the integrity of the vessel is the preventive element of the strategy, this reliability target  $(10^{-5}$ /y) is set for the vessel. It is not considered onerous for modern designs, operational data relating mainly to older equipment.

The balance of the reliability must therefore be borne by the mitigative elements of the strategy. These are the extract system for the facility worker, and the filtration system for the co-located worker and the public. The cell structure is passive, and no reliability target is assigned.

The reliability targets required for filtration unavailability and extract unavailability during the spill are the same and are 0.83. To set a more reasonable design target, and to ensure an adequate margin for the overall event frequency, these targets are both set as a probability of unavailability on demand of  $1 \times 10^{-2}$ . Based on previous operational experience both targets will be easily surpassed by the design as currently defined.

#### 3.8.4.2. Performance Requirements

Overall performance requirements of the control strategy for seismic events as a potential cause of vessel rupture must first be developed.

Design basis seismic events by definition have a frequency of 5 x 10<sup>-4</sup> per year (DOE 1996 and BNFL 1998g). This exceeds the target frequency for an SL-2 event. It is therefore necessary to specify that the vessel and its supports are seismically qualified to withstand the design basis seismic event. **Safety Function**. It is also necessary to specify that the cell structure will be qualified to withstand a seismic event sufficiently to prevent damage to the vessel from falling debris. **Safety Function**.

The performance requirements for the SSCs comprising the control strategy can now be defined:

#### Vessel and Associated Support Structure

The vessel and support structure should be sufficiently robust to receive and store the waste envelope for the required design life of the plant. These should also be designed to withstand the design basis seismic event.

#### The Cell Structure

The cell structure provides mitigation to the facility workers and the environment both due to normal operations and off normal events. The cell should therefore be qualified to withstand a seismic event to prevent failure of the structure and damage to the vessel. Sufficient shielding should also be provided to prevent a direct dose to the operator for normal operations and in the event of a vessel rupture. The cell structure must provide a minimum decontamination factor of 100 in order to provide sufficient protection to the facility worker in the event of a receipt tank rupture coincident with extract failure. This

decontamination factor will be achieved by minimizing the penetrations in the cell and ensuring it is well sealed.

#### The Ventilation Ductwork, Filters and Extract Fans

The C5 ventilation system, when operational, must at least ensure that the consequences to the facility worker and co-located worker from the tank rupture are reduced to less than the upper limit for SL-3. In both cases, the upper limit for SL-3 is 5 rem. This in fact, requires only a trivial increase in performance beyond that with which they are credited when in a failed state in the unmitigated consequence assessment.

To provide a reasonable design target and to ensure an adequate margin it is proposed that a target decontamination factor of 1,000 for the filters is specified to protect the co-located worker and public. **Design Assumption.** The filters should also be capable of withstanding the moisture loading which the event can impose on them without loss of performance. **Design Assumption.** When the filters are failed, the filter/ductwork must provide a combined decontamination factor of 10.

The decontamination factor across the cell structure and its penetrations to the operating area when the C5 extract is operating normally will be specified as 10,000. **Design Assumption.** 

Operational experience indicates that neither the filter decontamination factor of 1,000 nor the across cell structure decontamination factor of 10,000 will prove difficult to achieve.

#### 3.8.4.3. Administrative Measures

#### Cell, Vessel and Associated Support Structure

During the construction and commissioning phase of the project, in-cell structures, vessels, and pipe work are checked to confirm that they meet their design intent. It is typical that a certain vessels have a wall thickness fingerprint taken during construction or cold testing. This fingerprint provides a baseline measurement for cell inspection and vessel thickness checks through the lifetime of the facility.

The cell is structured such that any leakage from a vessel will be detected at a low point cell sump. These cell sumps are fitted with level instrumentation. Operators will be trained to identify, diagnose, and respond to abnormal operating conditions. Plant information will be relayed to the operator in such a manner to aid the operator in performing this duty. Typically, any deviation of the process from its normal operating condition will generate an alarm appropriate to its importance. This alarm will annunciate at the operator workstation or locally within the facility.

- Action the operator must perform to minimize the impact of the abnormality.
- The potential initiators.
- The follow up actions required, when plant conditions have been stabilized.

#### The Ventilation Ductwork, Filters, and Extract Fans

Normal operations will be conducted in accordance with approved operational safety requirements and in strict accordance with administrative and procedural control. Operators will be trained and assessed on the conduct of normal operations. Operational procedures, routine schedules, and records will augment training.

Arrangements for the examination, inspection, maintenance, and testing of all ITS equipment will be managed through a plant maintenance schedule (PMS). All maintenance activities will be carried out using appropriate maintenance instructions.

The operator will be required to monitor the differential pressure across the filters and initiate filter change when necessary. There is also a requirement for testing of the filters after installation. Operators will be suitably trained to perform these duties, as well as carry out inspection, testing and maintenance of the ductwork, filters and fans, when required. Operators will also be required to repair failed extract fans promptly to ensure adequate availability. On any failure of autochangeover, operators will be required to respond to alarms and initiate manual changeover.

#### 3.8.4.4. Administrative Standards

Operation of the TWRS facilities shall be conducted in accordance with proven practices from BNFL operations in the UK and the US. Arrangements will be in place to maintain and demonstrate compliance with the Safety Criteria detailed within the authorization basis.

Administrative arrangements will proved the framework for how facility operations will be conducted for all modes of operation be that normal, maintenance, or emergency preparedness.

The conduct of operation guidelines will be generated by the tailored application of appropriate sections of the following standards:

IAEA 50-C-0: Code on the Safety Nuclear Power Plants Operation DOE order 5480.19 "Conduct of Operations Requirements for DOE facilities". DOE order 4330.4B "Guidelines for the conduct of Maintenance at DOE Nuclear Facilities". "Appropriate standards" from the Institute for Nuclear Power Operations.

This framework of conduct will be implemented through:

- Management and organizational structure.
- Documents records, and certification, including response to abnormal operating conditions, key compliance recording and archiving.
- Structured training programs for all personnel, tailored to their roles and responsibility.
- Emergency preparedness implemented by having an emergency response structure, training, exercises, and procedures.
- Incident reporting arrangements.
- Safety documentation hierarchy, with appropriate flow down of information into operational documentation. All safety implications will be clearly identifiable within the operational procedures.
- Quality assurance
- Arrangements for the examination, inspection, maintenance, and testing of all ITS equipment.

• Labeling of ITS equipment clearly on the facility.

#### 3.8.4.5. Design Standards

#### Vessel and Associated Support Structure

• ASME VIII, Div 1 (5) – Basic Design Code

BNFL pays particular attention to the following active challenges to vessel integrity:

- 1. Stress levels high quality analysis by means of BNFL written automated finite element analysis parameterized macros for standard vessel configurations where required
- 2. Fatigue failure BNFL has its own S/N curves for fatigue in corrosive environments
- 3. Corrosion, both generalized and local e.g. crevice corrosion, end-grain corrosion (via audits BNFL has its own procedure and pro formas)
- 4. Manufacturing defects stringent NDE requirements and leak testing plus high levels of Quality Control

#### Provisions additional to ASME VIII

- More onerous NDT requirements, in particular more stringent radiography acceptance criteria
- Mandatory corrosion audit by qualified metallurgists
- Mandatory integral reinforcing of all branches (where reinforcing is required)
- All welds below liquid level and all pressure retaining welds are 100% radiographed
- 100% radiography on butt welds in heating/cooling coils
- 100% radiography on all welds below liquid level
- Quality Assurance to a nuclear standard BS 5882 "Specification for a Total Quality Assurance Programme for Nuclear Power Plants" or equivalent
- Strict manufacturing specifications defining material traceability, allowable contact materials, material testing, welder qualification, etc
- Performance monitoring during operation, e.g., corrosion samples, TV inspection, thickness measurement, leakage monitoring
- Design Validation
- Cumulative fatigue damage assessment and thermal stress analysis (including transients)

- Plant layout is examined with respect to such factors as avoiding the requirement for branches below liquid level and provision of sufficient space to allow dished end closures as opposed to flat end closures
- Restriction of allowable weldment types
- Ultrasonic examination of parent metal for defects which may cause lamelar tearing where "T" welds are used and the loading results in significant through-thickness stresses (e.g., lifting lugs, supports)
- Restrictions on the use and qualification of flanges

#### The Cell Structure

- ACI 349-90 Code Requirements for Nuclear Safety-Related Concrete Structures
- ANSI N690 Specification for the Design, Fabrication and Erection of Steel Safety-Related Structures for Nuclear Facilities
- ASCE 4, Seismic Analysis of Safety Related Nuclear Structure and Commentary
- ASCE 7, Minimum Design Loads for Buildings and Other Structures
- DOE-STD 1020 (1996) Natural Hazards Design and Evaluation Criteria for Department of Energy Facilities

#### The Ventilation Ductwork, Filters and Extract Fans

- SMACNA 80 and SMACNA 90 ductwork distribution system
- UL586, DOE-STD-3020-97 Filter units
- ANSI/ASME N509/N510, UL900 Filter housings
- ARI 670-90 Fans and Blowers
- ASME N509-89, Nuclear Power Plant Air Cleaning Units and Components
- ASME N510-1989 (Rev 1995) Testing of Nuclear Air Cleaning Systems
- ASME PTC 11-84 Performance Test Codes, Fans

#### 3.8.4.6. Standards Not in Standards Requirements Document

The Standards listed in the previous section are those identified in accordance with the integrated safety management process of DOE/RL/-96-0004. Of the standards identified above, the following are not contained in the *Standards Requirement Document*:

SMACNA 80 AND 90

UL900

# 3.8.5. Control Strategy Assessment

Consistent with the defense in depth principle, selection of a preferred control strategy for the HLW Receipt Vessel Rupture emphasizes preventive over mitigative measures. Engineered controls are preferred over administrative ones. Of engineered controls, passive features are preferred over active features. Ideally, the preferred control strategy incorporates both preventive and mitigative features (BNFL Inc 1998g).

The control strategy element selected to provide the primary physical barrier against radioactive releases from loss of the confinement function of the HLW Receipt Vessel is a robustly designed vessel. This is a passive barrier.

The secondary physical barrier was selected to be a filtered ventilation route from the cell in which the filters are also a passive barrier. This strategy provides protection to the public and both the facility and co-located worker. The passive feature of the shielded cell provides a secondary barrier against consequences to the facility worker, co-located worker and the public.

Additional design safety features are provided to reinforce the defense in depth of the facility against this hazard. The cell sump and emptying facility is a combination of active and administrative control which allows recovery from the event and can assist in reducing the duration of the release and therefore, the consequences. Level detection and alarms are provided to alert the operator to a leak in the cell. The provision of C5 extract fans contributes additional protection to the facility workers by maintaining a cell depression to prevent migration of activity through the cell fabric. The migration of activity to areas of lower potential contamination is prevented by the use of cascade interlocks which shut down other facility ventilation systems in the event of C5 extract fan failure.

In summary, the control strategy is a robustly designed vessel for primary confinement of the liquor and a lined shielded cell with a filtered ventilation route to provide secondary containment for all receptor groups. The cell sump level detection and emptying facility is included to provide additional defense in depth through aiming to reveal the event and recover the contents of the vessel as quickly as possible and mitigate the consequences of the release.

#### 3.8.5.1. Performance Against Common Cause and Common Mode Effects

The control strategy must remain functional in the event of any external or internal design basis or common cause/common mode events, including a seismic event.

The HLW vessels and the cell structure will be seismically qualified. Equipment within the cell will be seismically qualified as necessary to protect the process vessels. Therefore, an earthquake will not rupture a HLW vessel.

It is expected that the facility structure will provide adequate protection against other external Natural Phenomena Hazards (NPH), and man made external events such as an aircraft strike.

As noted in Section 3.8.2.5, no inherent common cause or common mode effects resulting in tank rupture were identified.

#### 3.8.5.2. Comparison with Top Level Principles

The preferred strategy is evaluated against a set of relevant top level radiological, nuclear and process safety standards and principles (DOE-RL, 1998b), as listed below:

#### 3.8.5.2.1. Defense in Depth DOE/RL-97-0006 4.1.1

Defense in depth is one of the general radiological and nuclear safety principles in DOE/RL-96-0006. SRD Volume II, Appendix B contains the BNFL *Implementing Standard for Defense in Depth*. This Implementing Standard governs application of the defense in depth principle on the TWRS-P project. To satisfy the application of defense in depth, the Implementing Standard requires that the elements of the control strategy must ensure "...that no one level of protection is completely relied upon to ensure safe operation. This safety strategy provides multiple levels of protection to prevent or mitigate an unintended release of radioactive material to the environment."

DOE/RL-96-0006 formulates the defense in depth principle in terms of the following six sub-principles:

- Defense in depth
- Prevention
- Control
- Mitigation
- Automatic Systems
- Human Aspects

SRD Volume II, Appendix B contains the BNFL *Implementing Standard for Defense in Depth.* This implementing standard governs application of the defense in depth principle on the TWRS-P project and addresses each of the six sub-principles in DOE/RL-96-0006. The following paragraphs describe application of the Implementing Standard for Defense in Depth to the control strategy for receipt vessel rupture.

#### 1. Defense in Depth (DOE/RL-96-0006 4.1.1.1)

DOE/RL-96-0006, Section 4.1.1.1, requires the following:

"To compensate for potential human and mechanical failures, a defense-in-depth strategy should be applied to the facility commensurate with the hazards such that assured safety is vested in multiple, independent safety provisions, not one of which is to be relied upon excessively to protect the public, the workers or the environment. This strategy should be applied to the design and operation of the facility." (DOE/RL-96-0006, Section 4.1.1.1)

Section 3.0 of the BNFL *Implementing Standard for Defense in Depth* addresses this aspect of the defense in depth principle specifically. For SL-2 events, Section 3.0 of the *Implementing Standard for Defense in Depth* requires:

- Two or more independent physical barriers to confine the radioactive material
- Consideration of the Single failure criterion
- A target frequency of  $<1.0 \times 10^{-4}/y$  for the SL-2 consequences

The control strategy provides a single physical barrier against the release of radioactivity from the HLW vessels. The vessels provide the first barrier. The second barrier consists of the cell structure and the C5 extract system.

The single failure criterion in the Implementing Standard requires that, given an initiating event, the control strategy must be able to tolerate a single failure of any single active component in the short term. The control strategy must also be able to tolerate a single passive failure in the long term. The single passive failure is to be a mechanistic failure (for example, pump seal leakage); the single passive failure is not a deterministic failure (for example, a pipe break).

The initiating event in this example is a random failure of the tank due to manufacturing errors. The control strategy satisfies the single failure criterion given the random tank failure as the initiating event. The C5 extract system provides the ventilation exhaust from the cell. The C5 extract includes 2 x 100% fans, dual off-site power supplies, and backup power. Therefore the C5 extract is not vulnerable to single active failures.

The control strategy includes elements that will mitigate the consequences of tank failure, namely, the confinement provided by the cell structure and associated filtered ventilation exhaust.

The analysis in section 3.3.5.6 indicates that the control strategy reduces the frequency of SL-2 level consequences from HLW tank rupture to be  $1.2 \times 10^{-6}$  per year. This satisfies the target frequency of  $1 \times 10^{-4}$  /y for SL-2 events by a wide margin.

The analyses in sections 3.3.5.3 and 3.3.5.4 show that the mitigating elements of the control strategy reduce the consequence from a tank rupture to SL-4 levels. The frequency of a tank rupture is  $1.2 \times 10^{-4}$ /y which is well within the Implementing Standard target frequency of  $1 \times 10^{-1}$ /y for SL-4 events.

Based on the results of the frequency estimate, the control strategy meets the target frequency with a large margin. Also, the frequency estimates indicate that the control strategy does not place excessive reliance on any single element to achieve this result.

The remaining 5 sub-principles are addressed below:

#### 2. Prevention (DOE/RL-96-0006 4.1.1.2)

The emphasis in the selected control strategy is on preventing the hazard by the provision of a high integrity vessel designed to withstand a wide range of initiating events. The vessel will be sufficiently robust in design and installation to achieve the required design life and provide an acceptably low initiating event frequency in combination with the mitigative features provided.

#### 3. Control (DOE/RL-96-0006 4.1.1.3)

The primary control element is the vessel itself, and the secondary control elements of the cell and filters for the strategy are passive features which require no control function.

#### 4. Mitigation (DOE/RL-96-0006 4.1.1.4)

The cell structure and C5 extract provide mitigation of the consequences of a release to the facility worker. The C5 filters mitigate the consequences of a release to the public and co-located worker. The

cell sump with instrumentation and emptying facility provides a route for recovery of the liquor in the event of a release, therefore reducing the duration and consequences of a release.

#### 5. Automatic Systems (DOE/RL-96-0006 4.1.1.5)

There is automatic changeover to standby fan in the event of a duty fan failure.

#### 6. Human Aspects (DOE/RL-96-0006 4.1.1.6)

Operating procedures will be defined which specify action to take when alerted to filter failure and detection of a leak in the cell. The human aspects associated with the monitoring and change of the filters and the action on leak detection in the cell follow proven examples and will be executed within the project procedures for training, qualification and quality assurance.

Since the Severity Level for the tank rupture hazard is SL-2, per Section 2.6.2 of the *Implementing Standard for Defense in Depth*, the control strategy must be reviewed against the human factors engineering criteria in IEEE Std. 1023-1988 6.1.1, as tailored by the *Implementing Standard*. **Open Issue.** 

Additional principles applicable to the design phase are:

#### 3.8.5.2.2. Operating Experience and Safety Research (DOE/RL-96-0006 4.1.2.4)

The control strategy selected is based on proven operating experience. The use of high integrity vessels for the storage of hazardous liquids is commonly employed in a number of industries. The provision of shielded cells, ventilation and filtration is commonly employed in the nuclear industry.

#### **3.8.5.2.3.** Proven Engineering Practices (DOE/RL-96-0006 4.2.2.1)

The provision of the vessel, cell confinement and C5 ventilation system is based on proven experience and practices in the nuclear industry.

#### 3.8.5.2.4. Common Mode/Common Cause Failures (DOE/RL-96-0006 4.2.2.2)

No specific common mode or common cause failure weaknesses beyond external events have yet been identified for the control strategy elements.

#### 3.8.5.2.5. Safety System Design and Qualification (DOE/RL-96-0006 4.2.2.3)

The system is designed for the contract waste envelope specification. The effects of aging will be accounted for in the design and are well documented for the strategy selected.

#### 3.8.5.2.6. Radiation Protection Features (DOE/RL-96-0006 4.2.3.2)

The control strategy is designed, in the first instance, to protect the facility worker, co-located worker and public from contamination due to normal operations. The design will be enhanced to ensure the same protection in the event of a vessel rupture.

# 3.8.5.2.7. Deactivation, Decontamination and Decommissioning (DOE/RL-96-0006 4.2.3.3)

The provision of a filtered, ventilation route from the cell will prevent build up of contamination within the cell and minimize potential dose uptake during decontamination and decommissioning activities

#### 3.8.5.2.8. Emergency Preparedness - Support Facilities (DOE/RL-96-0006 4.2.4)

The strategy has no foreseeable impact on the control room or emergency response center that may require to be manned after an event.

#### 3.8.5.2.9. Inherent/Passive Safety Characteristics (DOE/RL-96-0006 4.2.5)

The vessel, cell and filters provide passive safety features.

#### 3.8.5.2.10. Human Error (DOE/RL-96-0006 4.2.6.1)

The potential for human error is minimized in that human intervention is required only in a monitoring and maintenance capacity in terms of the filters. Monitoring of the cell sump and action on detection of a leak is an additional control assigned to mitigate the consequences or a release and is not required to meet the frequency targets.

#### 3.8.5.2.11. Instrumentation and Control Design (DOE/RL-96-0006 4.2.6.2)

Instrumentation is provided to assist in monitoring the status of the filters and cell sump level detection and alert the operator to abnormal situations

#### 3.8.5.2.12. Safety Status (DOE/RL-96-0006 4.2.6.3)

Leak detection in the cell and differential pressure across the filters will be provided at the control room safety status display.

#### 3.8.5.2.13. Reliability (DOE/RL-96-0006 4.2.7.1)

Reliability targets have been assigned to important to safety SSCs in Section 3.8.4.1.

#### 3.8.5.2.14. Availability, Maintainability and Inspectability (DOE/RL-96-0006 4.2.7.2)

The cell will not be normally manned and will not be suitable for regular operator access for maintenance, inspection or testing. However, alternative arrangements will be considered (e.g., CCTV, penetration suitable to allow camera insertion) to provide this facility.

#### 3.8.5.2.15. Pre-Operational Testing (DOE/RL-96-0006 4.2.8)

The control strategy will be subject to pre-operational testing of all its elements and experience currently exists for the testing of these elements.

#### 3.8.5.3. Mitigated Consequences

The C5 extract system mitigates the release from spilled radioactive waste in the process. The decontamination factor provided by the filters is 10<sup>3</sup>.

The C5 extract fans are provided for contamination control during normal operations and ALARA purposes. The release to the facility worker would be mitigated when the extract fans are working which increases the decontamination factor for the cell to  $10^5$  (BNFL plc 1997).

The mitigated dose consequences are therefore:

#### Facility Worker

Maximum inhalation dose =  $6 \times 10^{-3}$  rem (SL-4)

#### Co-located Worker

Maximum inhalation dose =  $6.9 \times 10^{-2} \text{ rem (SL-4)}$ 

#### **Public**

Maximum inhalation dose =  $2.3 \times 10^{-4} \text{ rem (SL-4)}$ 

#### 3.8.5.4. Frequency of the Mitigated Event

The initiating event is defined as a random failure of the vessel. *Sellafield Reliability Database* (BNFL plc 1998) indicates a rupture rate of  $1 \times 10^{-5}$  per year, for unpressurized vessels in non-aggressive conditions. There are 12 vessels in the facility that could potentially hold this hazardous inventory, therefore the initiating event frequency will be  $1.2 \times 10^{-4}$  per year. The initiating event frequency is the same as the mitigated sequence frequency.

#### **3.8.5.5.** Consequences with Failure of the Control Strategy (Including Mitigation)

Results of the consequence assessment for the unmitigated scenario are summarized below.

#### Facility Worker

Maximum inhalation dose = 6.0 rem (SL-2)

#### Co-located Worker

Maximum inhalation dose = 6.9 rem (SL-2)

#### **Public**

Maximum inhalation dose = 0.023 rem (SL-4)

#### 3.8.5.6. Frequency of the Control Strategy Failure

The frequency of the unmitigated release to the public and co-located worker is the frequency of vessel rupture multiplied by unavailability of the C5 extract filters. The information given in Section 3.8.4.1 is:

$$1.2 \times 10^{-4}/y \times 1 \times 10^{-2} = 1.2 \times 10^{-6}/y$$

The frequency of the unmitigated release to the facility worker is similarly the frequency of vessel rupture multiplied by the unavailability of the C5 extract. Again from Section 2.8.4.1 the data is:

$$1.2 \times 10^{-4}/y \times 1 \times 10^{-2} = 1.2 \times 10^{-6}/y$$

In both cases the target frequency for the severity level of the event is easily achieved.

In summary:

#### Summary of Results (Mitigated)<sup>a</sup>

Population	Dose (rem)	Severity Level	Frequency (y <sup>-1</sup> )
Facility Worker	6 x 10 <sup>-3</sup>	SL-4	1.2 x 10 <sup>-4</sup>
Co-located Worker	6.9 x 10 <sup>-2</sup>	SL-4	1.2 x 10 <sup>-4</sup>
Public	2.3 x 10 <sup>-4</sup>	SL-4	1.2 x 10 <sup>-4</sup>

<sup>&</sup>lt;sup>a</sup> Dominant pathway is inhalation

#### Summary of Results with Failure of Control Strategy<sup>a</sup>

Population	Dose (rem)	Severity Level	Frequency (y <sup>-1</sup> )
Facility Worker	6	SL-2	1.2 x 10 <sup>-6</sup>
Co-located Worker	6.9	SL-2	1.2 x 10 <sup>-6</sup>
Public	0.023	SL-4	1.2 x 10 <sup>-6</sup>

<sup>&</sup>lt;sup>a</sup> Dominant pathway is inhalation

# 3.8.6. Conclusions and Open Issues

A control strategy has been developed which is capable of providing an acceptable level of protection in the event of a receipt vessel rupture. The strategy is summarized in Table 3.8-6. The associated SSCs and standards have been identified to ensure the appropriate level of protection and reliability is provided.

A number of open issues have been identified which will require resolution as the detailed design develops:

- The mechanism for a leak to ground to occur due to tank rupture coincident with damage to the cell liner will be considered in a separate analysis as the detailed design develops.
- The control strategy must be reviewed against the human factors engineering criteria in IEEE Standard 1023-1988 6.1.1, as tailored by the Implementing Standard.

In addition to the open issues identified, a number of design and operational assumptions have been identified. Their continuing validity will be monitored throughout the design development.

RPT-W375-RU00001, Rev. 0 Section 3.8 Receipt Tank Rupture

Table 3.8-6. Design Data for HLW Receipt Vessel Rupture Control Strategy

Hazard Description	:				Initiator:	
HLW Receipt Vesse	HLW Receipt Vessel, V31001A/B, Rupture			Rupture from Weld Failure		
Selected Control Strategy	Important to Safety SSCs	<b>Safety Functions</b>	Design Safety Features	<b>Design Assumptions</b>		Operational Assumptions
1. Robust vessel design	Vessel	Provide primary containment for the HLW Withstand design basis seismic event. Withstand maximum buoyancy compression force.	allowance and strict material selection  Seismically qualified  NDT, inspection and QA during manufacture and construction		Z-101 solids are the ling material at risk.	Condition monitoring throughout design life Washed solids are stored at no more than 25 wt %.
	Vessel Supports	Restrain the tank during a maximum buoyancy-flooding event. Withstand design basis seismic event.				
2. Process cell	Cell structure	Provide secondary confinement in the event of a leak Provide adequate shielding following a loss of confinement. Withstand design basis seismic event to prevent damage to vessel through falling debris.	Seismically qualified, sufficient thickness to provide shielding, minimal penetrations, well sealed. Cladded and lined to prevent leak to ground.	to ope basis Flood design Proviot factor extrac Proviot factor C5 ex Cell a togeth protec hazaro	rill not be accessible trators on a routine ing considered as a load for cell. de decontamination of 10,000 with C5 t working de decontamination of at least 100 with tract failed. In the building structure there provide adequate the strong against external design and natural transment of a routine failed.	Adjacent out cell areas are not continually manned.

Table 3.8-6. Design Data for HLW Receipt Vessel Rupture Control Strategy

Hazard Description:					Initiator:	
HLW Receipt Vessel,	HLW Receipt Vessel, V31001A/B, Rupture Rupture Rupture					ailure
Selected Control Strategy	Important to Safety SSCs	Safety Functions	Design Safety Features	Design Assumptions		Operational Assumptions
3. C5 Ventilation extract	3a. Ventilation ductwork	Provide a contained route for removal of airborne contamination from the cell	Containment of airborne contamination		les a decontamination of 10 in the event of ailure	None
	3b. C5 Filters	Provision of a barrier against release to the atmosphere	Collection of airborne contamination Primary and secondary filter banks Instrumentation provided to detect and alarm failure	Filters to provide decontamination factor of at least 1,000 Filters can withstand the moisture loading which the spill event imposes		Operator will take action in the event of filter failure Filters are monitored to identify failure or blinding Filters are tested after installation
	3c. C5 Fans	Maintain depression in cell	of filters  2 x 100% duty/standby operation. Instrumentation provided to indicate failure/fans operating at sufficient capacity  Dual power supply and backup. Autochangeover to standby fan in the event of failure  Cascade interlocks to prevent migration of		mentation provided ect and alarm failure ers	Operator will initiate repair in the event of fan failure Operator will initiate manual changeover in the event that autochangeover fails.
			activity to areas of lower potential contamination in the event of a C5 fan failure			

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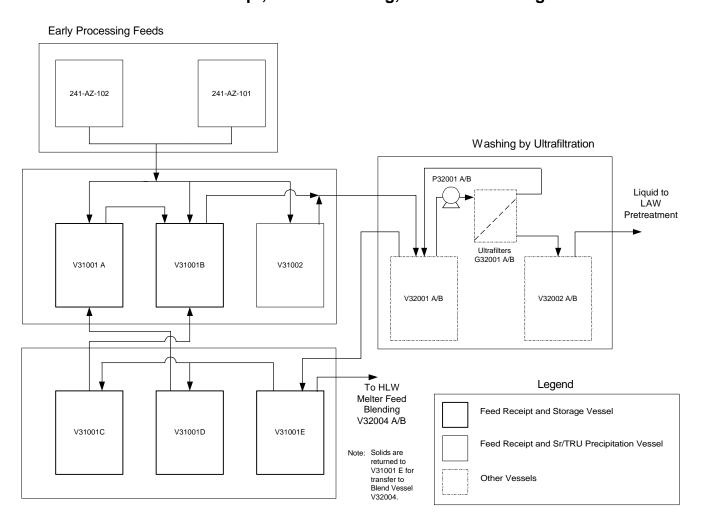
<sup>&</sup>lt;sup>b</sup> Copies of these references accompany this deliverable.

<sup>&</sup>lt;sup>c</sup> For access to these documents, contact the Design Safety Features Point-of-Contact through the office of Safety and Regulatory Programs, TWRS-P, Richland, Washington.

RPT-W375-RU00001, Rev. 0 Section 3.8 Receipt Tank Rupture

Kummerer M, 1999, Assignment of Severity Levels for Receipt Tank Rupture, CALC-W375PT-NS0001, BNFL Inc., Richland, Washington.  $^{\rm a}$ 

Figure 3.8-1. HLW Receipt, Solids Washing, and Solids Storage
HLW Receipt, Solids Washing, and Solids Storage



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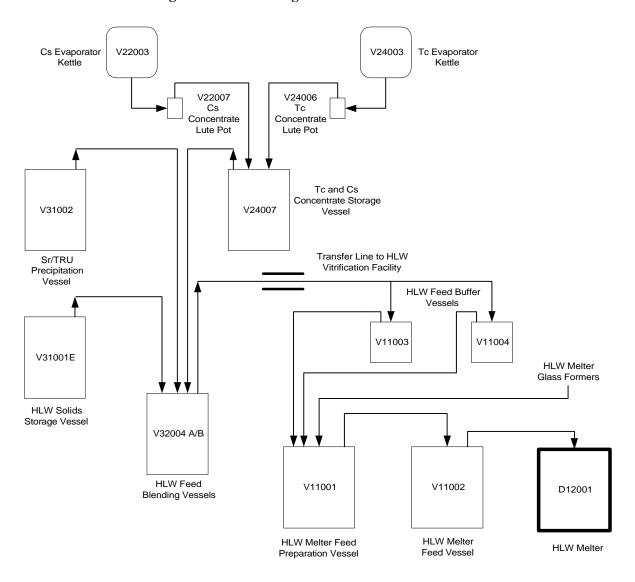


Figure 3.8-2. Blending of Feeds to the HLW Melter

Figure 3.8-3. Cell Sketch

